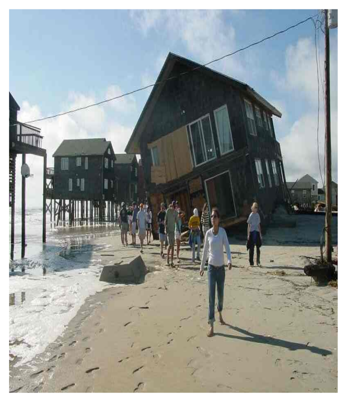
Big Picture:

- erosion accelerating
- chronic erosion →
  shoreline stabilization
  human decisions =
  f(coastline change)
- local stabilization affects regional
  shoreline change
  → other communities
  (adjacent and remote)
- Coastal property is valuable,
  nourishment is expensive;
  coastline change =
  f(human decisions)



Numerical Model
Couples physics, economics

With Sea-Level Rise and Changing Storms, Humans React to Shoreline Erosion— But Shorelines React Back

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NICHOLAS SCHOOL OF THE ENVIRONMENT AND EARTH SCIENCES DUKE UNIVERSITY

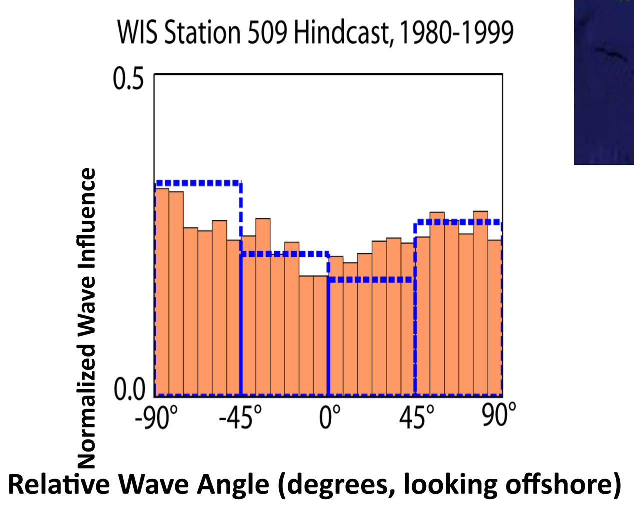
Duke CNCS Center for Nonlinear and Complex Systems; CENTER ON GLOBAL CHANGE DUKE UNIVERSITY

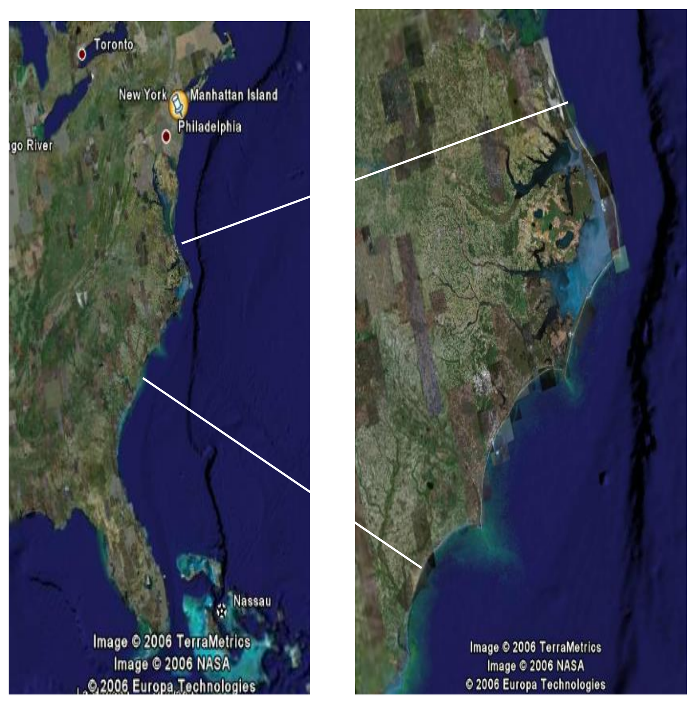
Biocomplexity/CHANS;
Geomorphology and Land-Use Dynamics

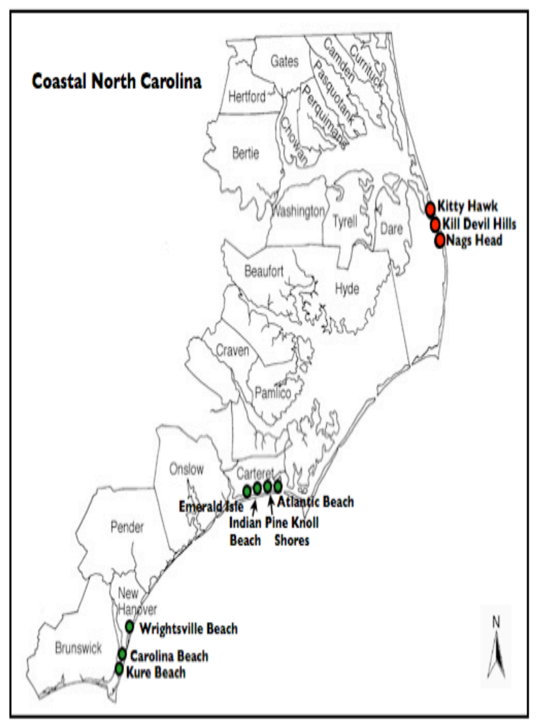
National Science Foundation WHERE DISCOVERIES BEGIN

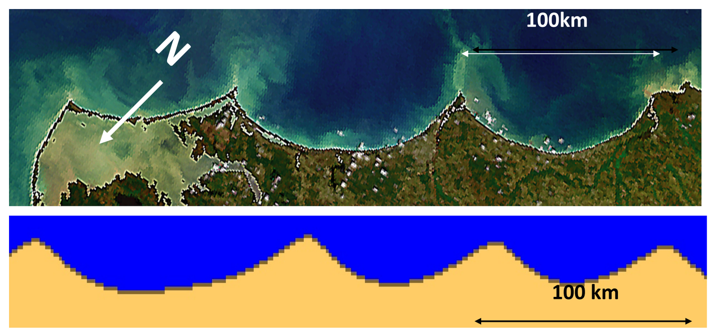
Case study: Carolina coastline

- wave-driven sediment flux
  → long-term change
- Wave climate (directions)
  → coastline shape







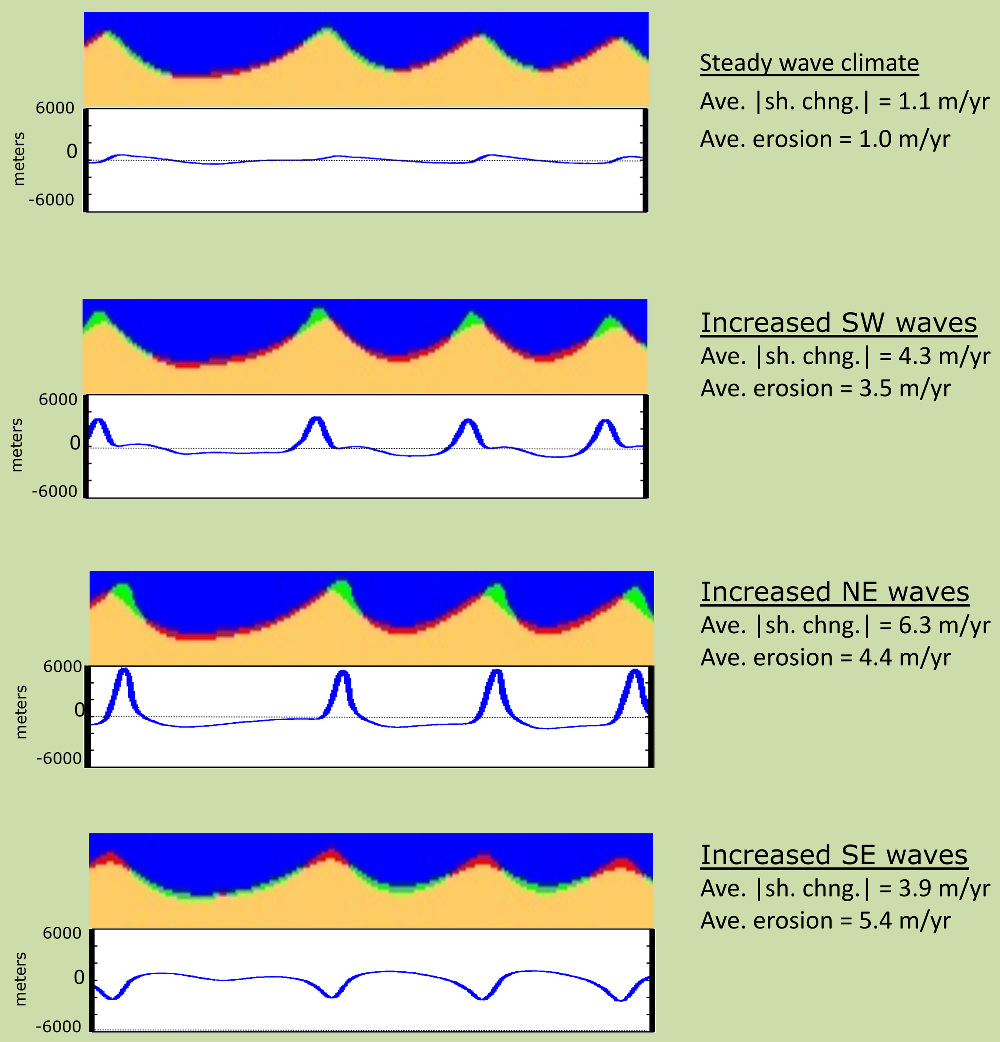


numerical-model coastline

Coastal towns, varying
Physical, economic conditions;
Sales price and beach width data
(1448 observations)

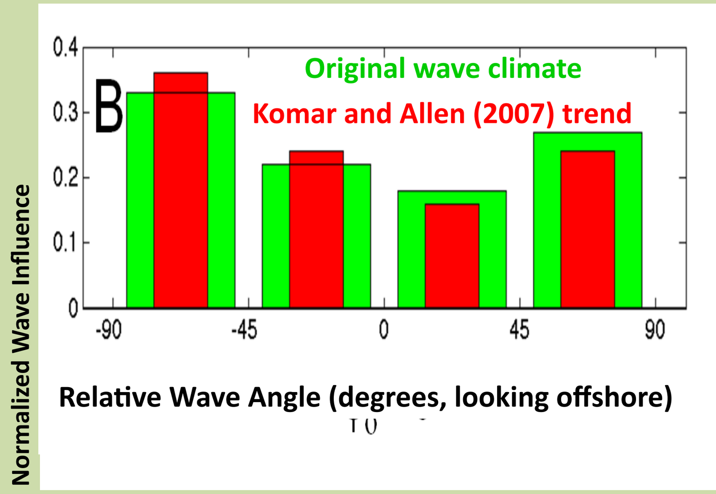
Storm-Climate Change Scenarios

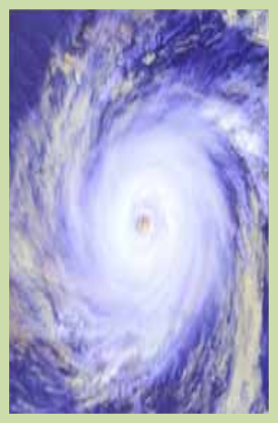
Changing wave climate changes coastline shape



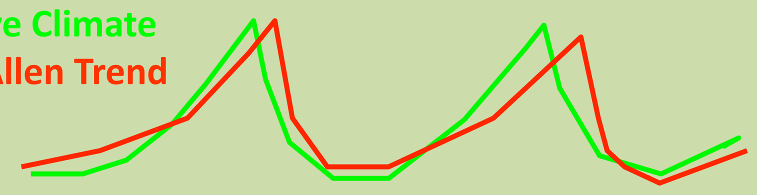
Increasing size of tropical-storm waves

Observed in recent decades



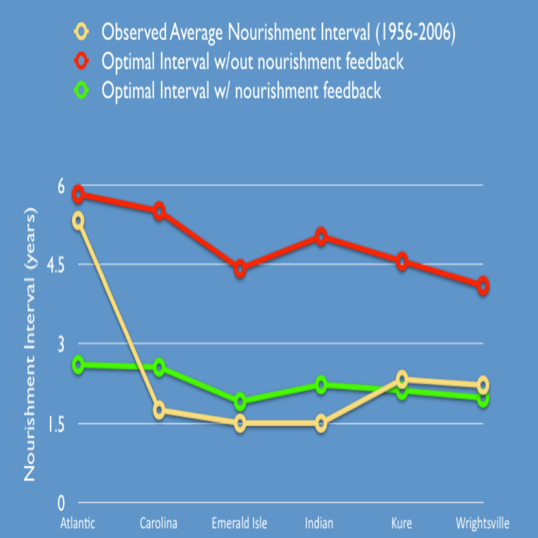


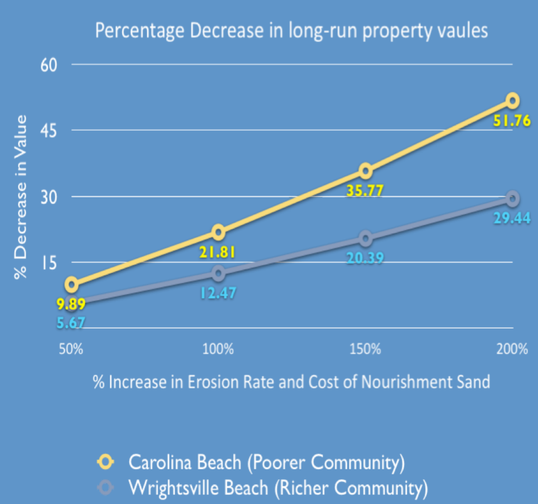
Modeling:



Test predictions on undeveloped capes
(w/Laura Moore, Owen Brenner) -- but with nourishment??

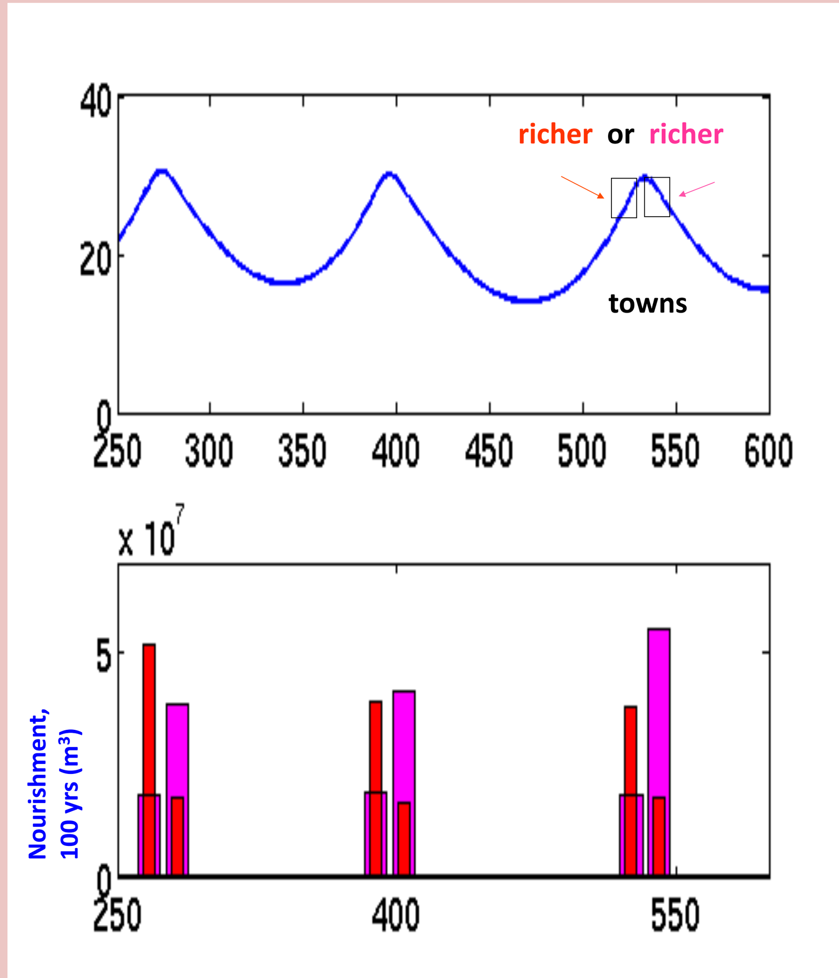
Empirical results confirm tight coupling between beach width and Property value





Forecasts for future Property value changes

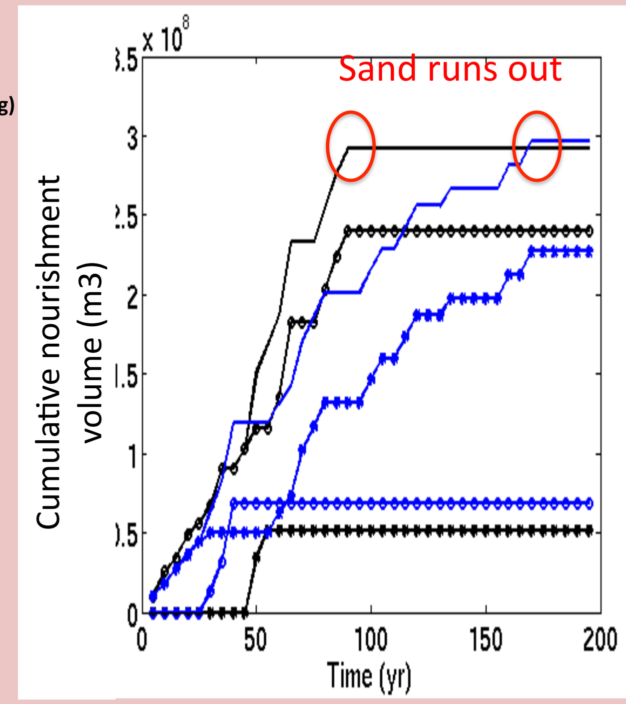
Economics depend on coupling



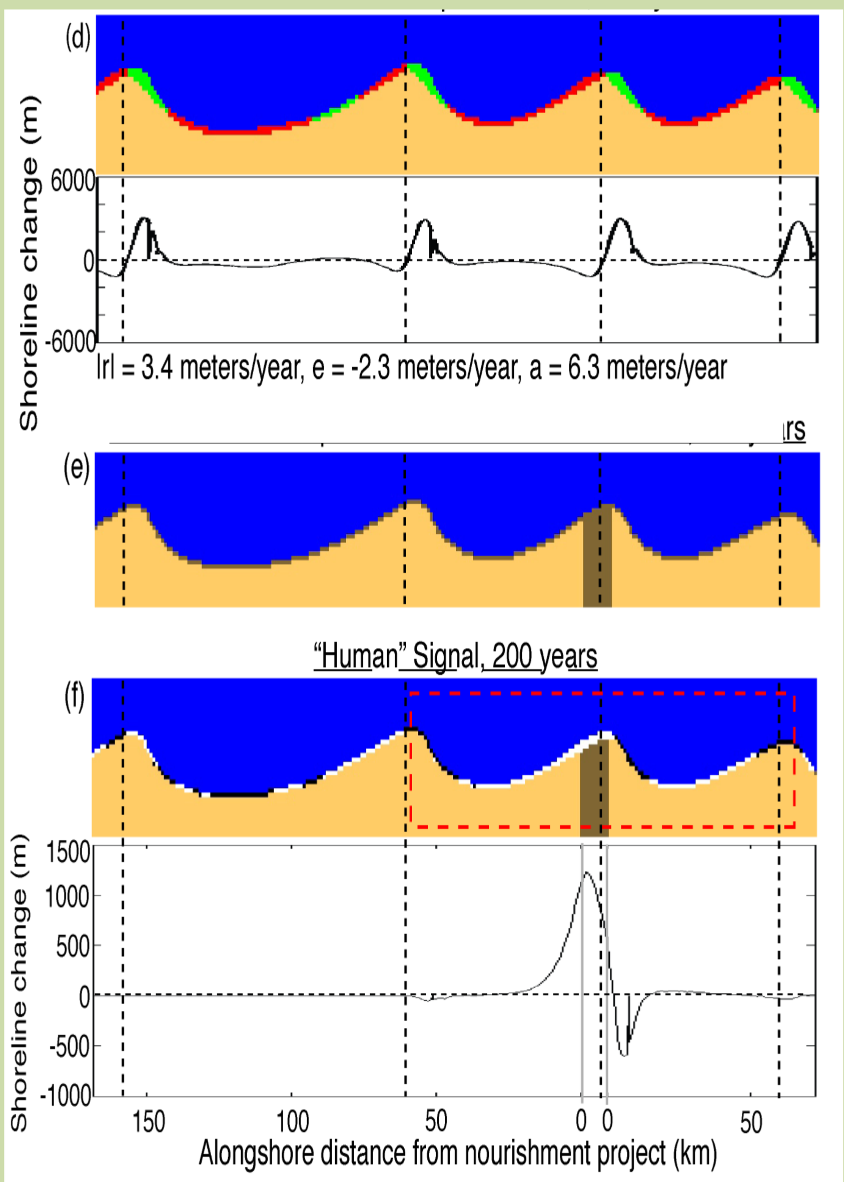
red = richer left of cape, magenta = v.v.
limited sand reservoir, increasing cost, less rich quit

Black: richer left of cape (more eroding)
Blue: richer to right (less eroding)
o = left flank
* = right flank

Fate of towns, resource differ



With shoreline stabilization?



wave-climate change

add local stabilization

Human signal
White = relative accretion
Black = relative erosion

Modeling beach nourishment decisions; Estimating the Economic Value of Beaches

Property Value = f(Property characteristics + Neighborhood + Environmental attributes)

Rooms, Lot size, Area; Year built — School district, Crime rate — Air Quality, Availability of open space, Beach Width

Wider beaches, lower storm risks, proximity to ocean are sources of value

How often should the beach be nourished to maximize net benefits?

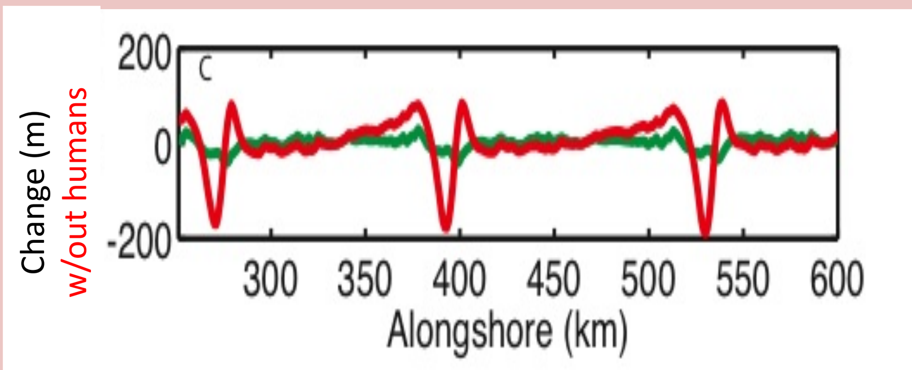
Benefits function

$$B(T) = \int_0^T e^{-\delta t} \delta A\left[x(t)^\gamma\right] dt$$

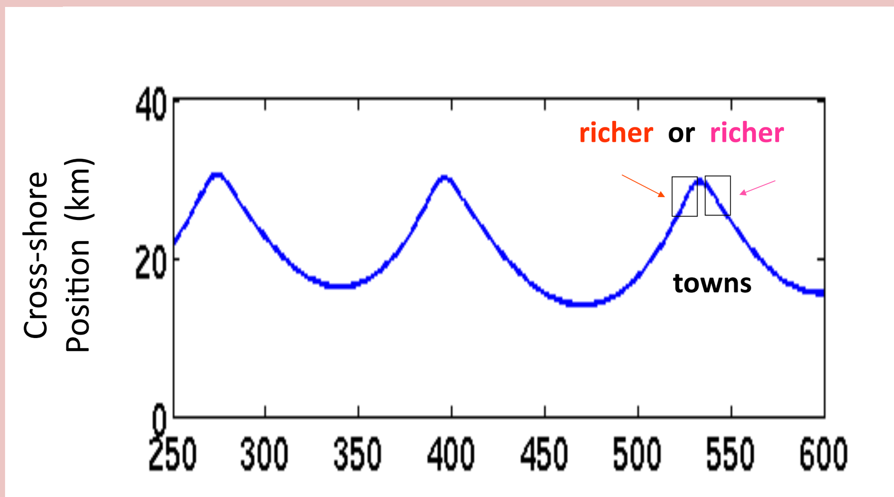
Baseline Property Value; Beach Width; Hedonic value of width

Couple economic, physical models

Climate forcing:
- sea-level-rise erosion (2 m/yr)
- and wave-climate change effects:

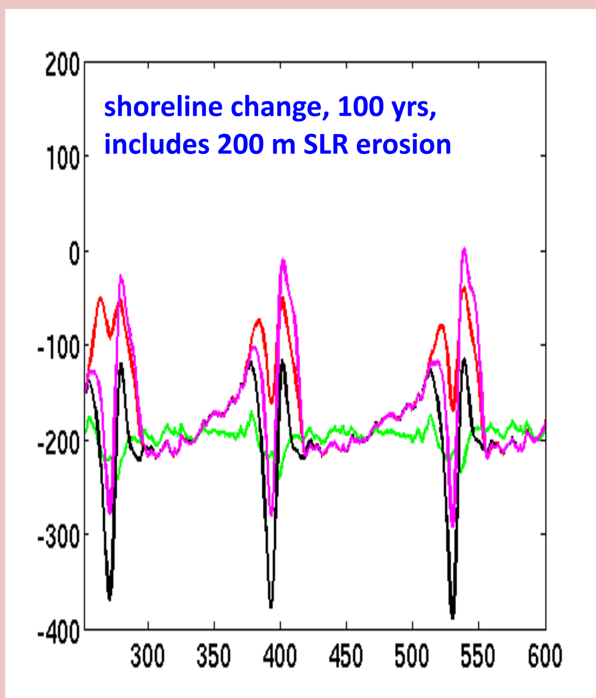


Economic forcing:
- limited sand reservoir (increasing nourishment costs)
- varying property value patterns (rel. to erosion pattern):



red = richer left of cape, magenta = v.v.
limited sand reservoir, increasing cost, less rich quit

Coastline evolution depends on coupling



Green: no nourish, const. climate
Black: no nourish, changing climate
Red: nourishment, richer to left of cape
Magenta: richer to right of cape

Coastline change, shape differ